Original scientific paper
DOI: /10.5513/JCEA01/24.2.3811
Journal of Central European Agriculture, 2023, 24(2), p.303-310

Effects of birth weight on puberty and the reproductive performance of crossbred *Moo Lath* x Duroc gilts

A születési súly hatása az ivarérésre és a szaporodásbiológiai teljesítményre keresztezett *Moo Lath* x Duroc kocasüldőknél

Somsy XAYALATH[1] (✉), Malam Abulbashar MUJITABA[1], Arth David Sol Valmoria ORTEGA[1], Rojesh KHANGEMBAM[1], Gabriella NOVOTNI-DANKO[1], József RATKY[2]

[1] Institute of Animal Science, Biotechnology and Nature Conservation, Faculty of Agricultural and Food Sciences and Environmental Management, University of Debrecen, Böszörményi Street 138, 4032 Debrecen, Hungary

[2] Department of Obstetrics and Farm Animal Medicine Clinic, University of Veterinary Science, István Street 2, 1078 Budapest, Hungary

✉ Corresponding author: xayalath.somsy@agr.unideb.hu

Received: November 28, 2022; accepted: March 1, 2023

ABSTRACT

This study aims to evaluate the effects of the birth weight of crossbred *Moo Lath* x Duroc (CMD) gilts on their puberty and first mating age, including the body condition and morphology. The litter size and birth weight of their offspring were also evaluated. Eighteen (18) CMD gilts were selected after weaning and kept in an individual pen 1.5 x 2 x 1 m after puberty. The gilts were grouped into three groups based on birth weight: groups A, B, and C (with <0.7, ≥0.7–0.9≤, and >0.9 kg, respectively). 15 mature purebred *Moo Lath* (PML) gilts reared by farmers were also involved in this study to compare the morphology between the CMD and PML at first mating. There was no difference in the age and body weight of CMD gilts at puberty and first mating among the studied groups. However, the gilts in group A showed a lower mean age at puberty, and marginally lighter body weight than those in groups B and C. Birth weight showed a significant influence on the backfat thickness at puberty and first mating (P<0.039 and 0.031). The CMD gilts could have their first mating at 193 days, that is at their 3rd and 4th estrous cycle, with approximately 40 kg of body weight, 38 mm of backfat thickness, 90 cm of heart girth, 100 cm of body length, and 51 cm height at wither. The CMD gilts' birth weight did not influence their litter size, but influenced their offspring's birth weight.

Keywords: first mating age, body condition, morphologies, *Moo Lath* pig

ÖSSZEFOGLALÁS

A tanulmány célja, hogy értékelje a keresztezett *Moo Lath* x Duroc (CMD) kocasüldők születési súlyának, kondíciójának és testméreteinek hatását az ivarérésre és a tenyésztésbe vétel idejére. Értékeltük a vizsgált süldők alomméretét és malacaik születési súlyát is. Tizennyolc (18) CMD választás utáni kocasüldőt vizsgáltunk ivarérésig 1,5 x 2 x 1 m-es egyedi karámban tartva. A süldőket 3 csoportra osztottuk születési súlyuk alapján: A, B, illetve C csoport (születési súly: <0.7; ≥0.7–0.9≤, illetve >0.9 kg). Tizenöt (15) tenyészített *Moo Lath* (PML) farmon nevelt süldőt is értékeltünk a vizsgálatban, hogy összehasonlítsuk az először filat CMD illetve PML süldők küllemét. Korban és testsúlyban nem volt szignifikáns különbség a vizsgált CMD süldők között ivarérettség idején, illetve az első termékenyítéskor. Ugyanakkor az A csoport egyedeinek valamivel alacsonyabb volt az átlagéletkora és súlya ivarérésкor mint a B és C csoport süldőinek. A születési súly szignifikánsan befolyásolta ivarérésкor és az első termékenyítés idején a hátszalonna vastagságot (P<0.039 és 0.031). A CMD süldők első termékenyítése 193 naposan történt a harmadik-negyedik ivarzásuk után, körülbelül 40 kg-os

súlyban, 38 mm-es hátszlonna vastagságnál, 90 cm-es övmérettel, 100 cm-es testhossznál, és 51 cm-es marmagasságnál. A CMD süldők születési súlya nem befolyásolta az alomméretüket, de hatással volt a malacaik születési súlyára. Az első termékenyítéskori testsúlyban nem volt szignifikáns különbség a CMD és PML süldők között, ugyanakkoraz átlagos testhosszuk és övméretük a CMD süldőknek valamivel nagyobb volt.

Kulcsszavak: első termékenyítés ideje, kondíció, küllem, *Moo Lath* sertés

INTRODUCTION

The indigenous pig breeds are vital for Lao economic development and food supply, especially the rural communities where approximately 9–14% of a household's annual income is from native pig production (Xayalath et al., 2020). *Moo Lath* pig is one of the famous native pig breeds in Laos. Unfortunately, this breed has been neither rightly (or properly) conserved as purebred for better breeding nor improved for better marketing strategies. Moreover, many drawbacks of the *Moo Lath* pig should be considered, such as a higher ratio of fat content, lower growth rate, small litter size, and high piglet mortality (Phengsavanh et al., 2010; Keonouchanh et al., 2011; Chittavong et al., 2012). The age at first estrous of *Moo Lath* gilts has not yet been scientifically proven. However, some reports indicated that *Moo Lath* gilts could reach puberty at about 150–180 days, with a body weight ranging from 30–39 kg (Wilson, 2007; Keonouchanh et al., 2011). On the other hand, small-scale farmers in Northern Laos reported that their *Moo Lath* reached puberty between 120–150 days old (Xayalath et al., 2021). The average litter birth weight of *Moo Lath* or other Lao indigenous piglets is typically between 0.5 and 0.7 kg (Phengvilaysouk et al., 2018; Manivanh et al., 2017). Subsequently, gilts derived from such litter reach puberty and first mating with a lighter body weight. Thus, enhancing the reproductive performance of indigenous pigs in Laos should include the birth weight. Therefore, this research was carried out between February 2021 to July 2022 at Dongkhamxang Agriculture Technical College (DATC) in Vientiane Capital, Laos. It aimed to evaluate the effects of birth weight of CMD gilts on age and body conditions at puberty and first mating, litter size, and birth weight of their offspring, including their morphologies.

MATERIALS AND METHODS

Animals, housing, and treatments

All animals used were raised and cared for in accordance with the Livestock and Veterinary Law of Laos (No. 08/NA-Laos, 11 April 2016), which addressed the protection and welfare of all animals used in this study. Additionally, the experiment aims to collect only primary farm data that does not involve collecting animal blood samples or other objects. The Laos Livestock and Veterinary Law procedures judged and declared this study a low risk of injury or harm to animal welfare. So, this study should be approval-free by the research ethics committee.

Eighteen (18) CMD piglets were selected (after weaning) as the best littermate from our previous report (Xayalath et al., 2022). The piglets were reared in 2 groups (9 per group) and fed the same diet (commercial feed) and water *ad libitum*. Each gilt was separated and kept in an individual pen (1.5 x 2 x 1.5 m or 3 m^2 for each) after puberty. The gilts were grouped into three groups based on birth weight: group A = 7 gilts with birth weight less than 0.7 kg; group B = 6 gilts between 0.7 and 0.9 kg; and group C = 5 gilts with over 0.9 kg. All gilts were bred twice using a local boar during their estrous cycle. The data regarding the morphology of 15 mature purebred *Moo Lath* gilts at first mating were randomly collected from different local farmers. Such information was obtained to enable us to compare the morphology of the CMD and PML gilts.

Body weight, body condition, and measurements

Every gilt was closely observed, and its growth performance was recorded. Soon after, the gilts attained puberty and their first mating. They were all weighed individually using a 300 kg digital weighing scale, and

measured for body length, height at wither, heart girth, and nose and ear length using a measuring tape (Figure 1). The FarmScan® L70 Eye muscles Veterinary Ultrasound (product of BMV Technology) was used to measure the backfat thickness at puberty and before the first mating of each gilt. The study was completed after the first farrowing of gilts, and all litter sizes and each newborn piglet were recorded.

a)

b)

Figure 1. Heart girth (a), and height at wither (b) measurement

Data collection and analysis

This study focused on collecting three data sets: i) the data on gilts' age and body conditions at puberty and first mating. ii) the data on the morphology of gilts at first mating, and iii) the litter size of each gilt and the individual birth weight of each piglet were recorded. Alongside collecting data from 18 CMD gilts from our experimental pig farms, morphological data were also collected from 15 mature PML gilts by randomized selection from 8 different local farmers in Vientiane Capital before first mating.

One-way analysis of variance (ANOVA) in the SPSS statistics software version 26 (2019), was used to analyze and check the data related to the age and body conditions of gilts at puberty and first mating, including litter size and their offspring birth weight. The data on morphologies at first mating of the CMD and PML gilts were compared using the Independent-Samples T-Test in the SPSS software. The correlations between the birth weight of the gilts and their performance parameters were also analyzed using the Bivariate correlations function in the SPSS. The statistical model used for evaluating the influence of gilt's birth weight on their piglet performance was $Y_{ij} = \mu + A_i + E_{ij}$. Where Y_{ij} is the dependent variable, μ is the overall mean, A_i is the influence of gilt's birth weight $_i$ on their litter size and birth weight of their offspring, E_{ij} is the random error.

RESULTS AND DISCUSSION

The birth weight did not significantly influence (P>0.05) the age at puberty and first mating of the CMD gilts. The mean age at puberty and first mating of the CMD was approximately 137.47±10.07 and 193.27±16.71 days, respectively. The gilts in group A, observed marginally earlier puberty than those in groups B and C (131.86±8.32, 142.75±13.57, and 142.00±3.56 days, respectively). These findings are in line with the report of Patterson et al. (2020). Similarly, there was no significant difference (P = 0.826) in the mean body weight at the onset of puberty and first mating (31.35±5.44 and 39.69±5.91 kg, respectively). Interestingly, gilts in group A reached puberty at an average weight of 30.62±5.09 kg, while gilts in group B exhibited puberty at 32.85±8.63 kg, and those in group C at 31.13±2.73 kg (Table 1). From this point, the body weight of *Moo Lath* gilts/sows remains a constraint or a bottleneck issue impeding the growth of indigenous pig progress in Laos. Although the gilts used in this study were the crossbred *Moo Lath* x Duroc, there was not so much difference in the body weight at first mating with the purebred *Moo Lath* gilts reared by farmers, which usually ranges between 24 to 30 kg.

In this study, the age of CMD gilts varied from 168 to 229 days in their 3rd or 4th estrous cycle, with an average body weight of 39.69±5.91 kg and 38.18±8.29 mm of backfat thickness at first mating. These results did not

differ from the purebred *Moo Lath* reared by small-scale farmers, with an average age of 195 days (ranging from 180–210 days) and 39 kg live weight at first mating (Keonouchanh et al., 2011). Nevertheless, the present result recorded a slightly earlier age at puberty than NongTaeng black pig (CMD x CMD), which observed puberty at 203 days (73.60 kg) and the age of 226 days (80.30 kg) at first mating (NAFRI, 2020). In the present study, the age at puberty and at first mating of the CMD gilts also differed from other indigenous pig breeds in the ASEAN countries and other regions. For instance, the Vietnamese *Mong Cai* pig attained puberty at 210 days (ranging from 180–240 days) with a body weight of about 35 kg (Dang-Nguyen et al., 2010). The native pig breeds in Timor East, the gilts reach puberty at 179 days and 275 days at first mating (Noronha et al., 2017). It is similar to the Chinese *Jiangxing* black pig, in which the gilts reach their sexual maturity and age at first mating in approximately 180–210 days (Li et al., 2019). Both PML and CMD gilts reach first puberty and first mating ages almost twice younger than the *Xishuangbanna* pig, a Chinese indigenous pig breed reared by small-scale farmers in Southwestern China, which might be one of *Moo Lath*'s ancestors. The *Xishuangbanna* gilt reached its first farrowing at about 435 days (Riedel et al., 2014).

The present study showed differences from European indigenous pig breeds, especially the optimal age at first mating. For instance, Hungarian Mangalica gilts attained puberty at approximately 210 to 240 days (Egerszegi et al., 2018), but most farmers would not allow them to be bred before 270 days old or less than 90 kg of live weight at first mating (Szabó et al., 2013). Spanish Iberia pig is another popular European indigenous pig breed, with a first farrowing observed around 398 days (ranging from 300 to 495 days) (Nieto et al., 2019). On the other hand, there was a wide range for the optimal age (170–260 days) at the first mating of commercial gilts, which could affect their lifetime performance (Joab, 2019). Due to the limited information on Lao indigenous pig breeds regarding their reproductive performance compared to other popular indigenous pig breeds in other regions. The optimum age and body conditions related to reproductive performance and longevity of the CMD gilts need further scientific studies.

On the other hand, the birth weight of the CMD gilts showed a significant difference in backfat thickness at puberty ($P<0.039$). Heavier gilts at birth showed thicker backfat at puberty than those with lighter birth weights. As shown in Table 1, gilts in group C had around 44.69±5.77 mm of backfat at puberty, while those gilts in group A and B were 35.14±5.39 mm and 43.28±6.83 mm, respectively. Similarly, the gilts in group C had a thicker backfat at first mating, approximately 44.66±6.84 mm, compared to 32.66±4.04 mm in group A and 41.35±10.04 mm in group B gilts. Unfortunately, currently, Lao lacks evidence of *Moo Lath*'s backfat thickness related to their reproductive performance to compare with these findings. The birth weight of CMD gilts did not significantly influence their litter size ($P<0.826$). Although, the mean litter size of gilts in group A (gilts born with less than 0.7 kg of birth weight) was 6.29±0.76, which was larger than those in groups B (6.00±0.82) and C (6.00±1.16). This finding is opposed to the report of Magnabosco et al. (2016), who indicated that gilts with less than 1 kg of birth weight produced less in the total born piglets than those born with heavier birth weight. On the other hand, the birth weight of CMD gilts influenced the birth weight of their offspring ($P<0.042$). The mean birth weight of piglets born from the gilts in group C produced was 0.55±0.33 kg, which was slightly heavier than those born from the gilts in groups A and B, which had approximately 0.50±0.03 kg and 0.52±0.3 kg, respectively (Figure 2). However, there was no significant difference in the birth weight of piglets born between groups, but their growth performance or daily weight gain from birth to weaning might be more substantially different due to the gilts' birth weight as described by de Almeida et al. (2014). The unclear influence of the birth weight of piglets in this study was assumed to be associated with two factors. The first factor *Moo Lath* gilts or sows, hardly produced piglets with over 1 kg of birth weight; it usually ranges from 0.5 to 0.7 kg. The second factor might be associated with the body weight of the CMD gilts at first mating, with about 39.69±5.91 kg on the average body weight of gilts in this study. Especially,

Table 1. Comparison of the ages at puberty and first mating and body condition of crossbred *Moo Lath* x Duroc gilts

Parameters	Group A	Group B	Group C	Mean ± SD	*P*-value
Number of gilts	7	6	5	-	-
Age at puberty, days	131.86±8.32	142.75±13.57	142.00±3.56	137.47±10.07	0.126
Body weight at puberty, kg	30.62±5.09	32.85±8.63	31.13±2.73	31.35±5.44	0.826
Backfat thickness at puberty, mm	35.14±5.39^{a}	43.28±6.83^{b}	44.69±5.77^{b}	39.86±7.12	0.039
Age at first mating, days	195.57±16.49	198.00±22.43	184.50±10.53	193.27±16.71	0.493
Body weight at first mating, kg	36.60±5.86	41.85±6.08	42.93±3.84	39.69±5.91	0.162
Backfat thickness at first mating, mm	32.66±4.04^{a}	41.35±10.04^{ab}	44.66±6.84^{b}	38.18±8.29	0.031

$^{a, b}$: Means in the same row with different superscripts differ significantly (P<0.05). Group A: gilts with a birth weight less than 0.7 kg; Group B: gilts with a birth weight of ≥0.7–0.9 kg≤; Group C: gilts born with over 0.9 kg of birth weight.

the mean body weight of gilts at first mating in group A was only 36.60 kg, the capacity of their uterine might not have enough space to hold six or seven fetuses (Xayalath et al., 2022), which birth weight might have an impact. Due to a lack of information regarding Lao indigenous pig breeds or CMD gilts. All studies related to the performance of Lao indigenous pigs, including the CMD gilts and sows, are required.

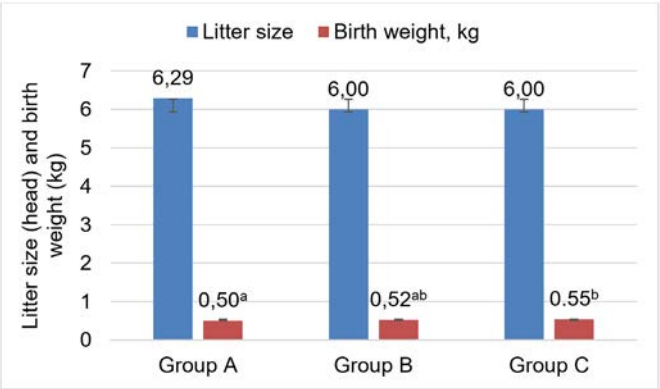

Figure 2. Comparison of the litter size and birth weight based on the gilts' birth weight; Group A, B, C: groups gilts based on their birth weight with < 0.7, ≥0.7–0.9≤, and > 0.9 kg, respectively. ^{a,b},: Means in the same row with different superscripts differ significantly (P<0.05).

The birth weight of CMD gilts was estimated to have a strong positive correlation to both backfat thickness at puberty and first mating. Nevertheless, the birth weight of CMD gilts was neither correlated to their litter size nor to their offspring's birth weight (Table 2). Similarly, the age at puberty was estimated to correlate with the body weight at puberty and strongly correlated with the body weight at first mating. The backfat thickness of CMD gilts at puberty was substantially associated with the backfat thickness at first mating. However, there was no significant correlation between body weight at first mating of the CMD gilts and their offspring's birth weight. But the age of the gilts at first mating seems to negatively impact litter size.

The CMD gilt has a significantly taller (P<0.026) wither height than PML gilts (50.53±42.55 vs. 42.55±11.16 cm; Figure 3). The average body length and heart girth of CMP gilts at first mating are longer (P>0.05) than the PML gilts (99.87±8.65 and 90.20±8.36 cm vs. 89.49±9.74 and 80.95±9.24 cm, respectively).

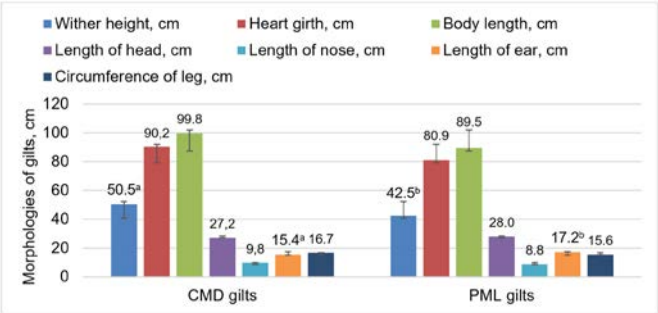

Figure 3. Comparison of the morphology of the CMD and PML gilts at first mating; a,b,: mean in same bar color with different letter differ significantly (P<0.05); CMD: crossbred *Moo Lath* x Duroc gilts; PML: Purebred *Moo Lath* gilts.

Table 2. Correlation between the birth weight of the CMD gilts and their performance parameters

	BWG	AP	BWP	BFP	AFM	BWM	BFM	LS	BWPi
BWG		0.436	0.058	0.643**	-0.310	0.467	0.692**	0.117	0.484
AP	0.436		0.551*	0.394	0.288	0.738**	0.271	0.188	0.108
BWP	0.058	0.551*		0.233	0.521*	0.677**	-0.083	0.230	0.129
BFP	0.643**	0.394	0.233		-0.327	0.354	0.706**	-0.012	0.385
AFM	-0.310	0.288	0.521*	-0.327		0.272	-0.479	-0.110	-0.120
BWM	0.467	0.738**	0.677**	0.354	0.27		0.280	0.299	0.263
BFM	0.692**	0.271	-0.083	0.706**	-0.479	0.280		0.081	0.477
LS	-0.117	0.188	0.230	-0.012	-.0.110	0.299	0.081		-0.387
BWPi	0.484	0.108	0.129	0.385	-0.120	0.263	0.477	-0.387	

BWG: birth weight of gilts; AP: age at puberty; BWP: body weight at puberty; BFP: backfat at puberty

Nevertheless, the heart girth and body length of CMD gilts were not significantly ($P>0.05$) different from the mature PML gilts reared by local farmers. But, the average body length and heart girth of CMD gilts at first mating are longer, almost 10 cm more than the mature PML gilts. However, the present results slightly differ from Nong Taeng black pig (CMD x CMD), with an average wither length at first mating of about 61.33 cm and a body length of about 83.17 cm (Keonouchanh, 2018). But the body weight at first mating of CMD was significantly smaller, almost twice times compared to Nong Taeng black pig (39.86 vs. 80.33 kg). The correct reason for this difference still needs more scientific studies to approve. But, the difference between the age at first mating might be one of the pre-assumption when our team allowed the gilts to be mated at 193 days while Nong Taeng black pig was 226 days (Keonouchanh, 2018). Nevertheless, we observed a longer body length and heart girth of the CMD than PML gilts (Figure 4) and MPL sows raised by local farmers, with an average of about 92.5 and 93 cm, respectively (Keonouchanh et al., 2011).

a)

b)

Figure 4. The general appearance of PML gilt (a) and CMD gilt (b)

CONCLUSIONS

The present results concluded that birth weight did not influence the age and body weight at puberty and first mating of the F-1 crossbred *Moo Lath* x Duroc (CMD) gilts, while the backfat thickness did. The CMD gilts can be bred for the first time at about 193.27 days old on their 3rd or 4th estrous cycle, with a mean body weight of about 39.69 kg and a backfat thickness of approximately 38.18 mm. The birth weight of the CMD gilts did not influence their litter size; however, it influenced the birth weight of their offspring. In the case of the CMD gilts in good management, they could reach a mean body length, heart girth, and height at wither at first mating of around 100, 90, and 51 cm, respectively.

ACKNOWLEDGEMENT

The author acknowledges the Stipendium Hungaricum Scholarship Program, which provided me with the opportunity to study in Hungary. The authors acknowledge all corning teams from Dongkhamxang Agriculture Technical College (DATS), Laos. Who have strived hard to carry out the experiment and data collection. Similarly, the authors also acknowledge U.D.A. FARM, who supported us with the Duroc semen used in the experiment. Last but not least, the authors also acknowledge the VITAFORT CO., in Laos, who supported the feed for the experiment.

REFERENCES

Chittavong, M., Lindberg, J.E., Jansson, A. (2012) Feeding regime and management of local Lao pigs in Central Lao PDR. Tropical Animal Health and Production, 45, 149-155. DOI: https://doi.org/10.1007/s11250-012-0186-1.

Dang-Nguyen, T.Q., Tich, N.K., Nguyen, B.X., Ozawa, M., Kikuchi, K., Manabe, N., Ratky, J., Kanai, Y., Nagai, T. (2010) Introduction of various Vietnamese indigenous pig breeds and their conservation by using assisted reproductive techniques. Journal of Reproduction and Development, 56 (1), 31-35. DOI: https://doi.org/10.1262/jrd.09-165K.

de Almeida, M., Bernardi, M.L., Motta, A.P., Bortolozzo, F.P., Wentz, I. (2014) Effect of birth weight and litter size on the performance of Landrace gilts until puberty. Acta Scientiae Veterinariae, 42 (1), 1-8.

Egerszegi, I., Brüssow, K-P., Sarlós, P., Manabe, N., Rátky, J. (2018) Reproductive Capacity of Mangalica pigs – What is the Reality? Archivos de Zootecnia, 81-86. DOI: http://dx.doi.org/10.21071/az.v67iSupplement.3578.

Joab, M.C. (2019) Determining the optimal age of breeding gilts and its impact on lifetime performance, Literature review. Acta Agraria Debreceniensis, 1, 15-20. DOI: https://doi.org/10.34101/actaagrar/1/2363.

Keonouchanh, S., Egerszegi, I., Ratky, J., Bounthong, B., Manabe, N., Brüssow, K-P. (2011) Native pig (Moo Lat) breeds in Lao PDR. Archives Animal Breeding, 54, 600-606.

Keonouchanh, S. (2018): KOPIA Project Final Report year 2016- 2018. The improved livelihood of farmers by chicken and pig raising in Mork district, Xiengkhuang Province. National Agriculture and Forestry Institute of Laos.

Li, Y., Wang, C., Huang, J., Liu, G., Zhao, S., Yuan, J., Liu, X. (2019) Effects of primary breeding day age on the reproductive performance of *Jiaxing* black pig. Chinese Journal of Animal Science, 55 (2), 109-111.

Magnabosco, D., Bernardi, M.L., Wentz, I., Cunha, E.C.P., F.P. Bortolozzo, F.P. (2016) Low birth weight affects lifetime productive performance and longevity of female swine. Livestock Science, 184, 119-125. DOI: https://doi.org/10.1016/j.livsci.2015.12.008.

Manivanh, N., Inthapanya, S., Savathvong, S., Schiller, J.M. (2017) Improving the reproduction of local pigs in Northern Lao PDR by crossing with Vietnamese *Mong Cai* pigs. The Lao Journal of Agriculture and Foresty, 36, 17-32.

NAFRI (National Agriculture and Forestry Research Institute of Laos). (2020) Report. 20 years for livestock research and development in Laos. NAFRI. pp. 12-21.

Nieto, R., García-Casco, J., Lara, L., Palma-Granados, P., Izquierdo, M., Hernandez, F., Dieguez, E., Duarte, J.L., Batorek-Lukač, N. (2019) Ibérico (Iberian) Pig. In M. Candek-Potokar, & R. M. N. Linan (Eds.), European Local Pig Breeds - Diversity and Performance. A study of project TREASURE. IntechOpen. DOI: https://doi.org/10.5772/intechopen.83765.

Noronha, A.M.C.G., Norondha, C.G., Agbisit, A.M., Amor, C., Estrella, S., Dizon, J.T., Costa, A.M.D., Narondha, G. (2017) Productivity of native pigs in subsistence farming and their roles in community development in Timor-Leste. Thesis (MS in Animal Science), University Library, University of the Philippines at Los Baños.

Patterson, J., Bernardi, M.L., Allerson, M., Hanson, A., Holden, N., Bruner, L., Pinilla, J.C., Foxcroft, G. (2020) Associations among individual gilt birth weight, litter birth weight phenotype, and the efficiency of replacement gilt production. Journal of Animal Science, 98 (11). DOI: https://doi.org/10.1093/jas/skaa331.

Phengsavanh, P., Ogle, B., Stür, W., Frankow-Lindberg, B.E., Lindberg, J.E. (2010) Feeding and performance of pigs in smallholder production systems in Northern Lao PDR. Tropical Animal Health and Production, 42, 1627-33. DOI: https://doi.org/10.1007/s11250-010-9612-4.

Phengvilaysouk, A., Lindberg, J.E., Sisongkham, V., Phengsavanh, P., Jansson, A. (2018) Effects of provision of water and nesting material on reproductive performance of native *Moo Lath* pigs in Lao PDR. Tropical Animal Health and Production, 50, 1139-1145. DOI: https://doi.org/10.1007/s11250-018-1541-7.

Riedel, S., Schiborra, A., Hülsebusch, C., Schlecht, E. (2014) The productivity of traditional smallholder pig production and possible improvement strategies in *Xishuangbanna*, South Western China. Livestock Science, 160, 151-162. DOI: https://doi.org/10.1016/j.livsci.2013.11.009.

Szabó, P., Papp, C., Tóth, P., Vásárhelyi, B. (2013) Mangalica Pig Register. National Association of Mangalica Breeders. Debrecen, Hungary, pp. 18-29.

Wilson, T. R. (2007) Status and prospects for livestock production in the Lao People's Democratic Republic. Tropical Animal Health and Production, 39, 443-452. DOI: https://doi.org/10.1007/s11250-007-9048-7.

Xayalath, S., Balogh, E., Rátky, J. (2020) The role of animal breeding with special regard to native pigs of food supply and rural development in Laos. Acta Agraria Debreceniensis, 1, 149-154. Available: https://ojs.lib.unideb.hu/actaagrar/article/view/3771 [Accessed 7 November 2022].

Xayalath, S., Novotni-Dankó, G., Balogh, P., Brüssow, K.P., Rátky, J. (2021) Reproductive performance of indigenous Lao pigs reared by small-scale farmers in northern provinces of Laos. Archives Animal Breeding, 64, 365-373. DOI: https://doi.org/10.5194/aab-64-365-2021.

Xayalath, S., Novotni-Danko, G., Rátky, J. (2022) The role of sstrous synchronization and artificial insemination in improving the reproductive performance of *Moo Lath* gilts. Agriculture, 12, 1549. DOI: https://doi.org/10.3390/agriculture12101549.